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WATER RESOURCES STUDY, PECAN BAYOU
WATERSHED, COLORADO RIVER BASIN,
TEXAS

Public Health Service
Dallas, Texas

October 1962

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WATER RESOURCES STUDY

PECAN BAYOU WATERSHED

COLORADO RIVER BASIN A

TEXAS

Study of Potential Needs and Value of
Water for Municipal, Industrial, and
Quality Control Purposes



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DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service, Region VII
Dallas, Texas

In Cooperation with the

DEPARTMENT OF THE ARMY
U. S. Army Engineer District - Fort Worth, Texas

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I. INTRODUCTION

General

In a letter dated June 8, 1959, the Corps of Engineers, Fort Worth District, requested "Views and recommendations of HEW on present and prospective needs for municipal and industrial water supply for Brownwood and desirability of meeting these needs from the Pecan Bayou project." In compliance with this request, a report entitled "Municipal and Industrial Water Requirements, Pecan Bayou, Colorado River Basin, Texas" was prepared and submitted in July 1961. Since the preparation of this report, there have been several changes in: (1) the laws governing water resource planning; (2) the planning policies of Federal agencies; and (3) the plans for the reservoir projects included in the original request.

Authority

The Corps of Engineers, Fort Worth District, in a letter dated July 13, 1962, provided revised data and requested a supplement to the July 1961 report.

This study has been made in accordance with: (1) the Water Supply Act of 1958 (Public Law 85-500, Title III) and a Memorandum of Agreement between the Department of the Army and the Department of Health, Education, and Welfare, dated November 4, 1958; and (2) the Federal Water Pollution Control Act (Public Law 84-660) as amended by Public Law 87-88.

Purpose and Scope

This report indicates the requirements for municipal, industrial, and water quality control purposes to the year 2070 in the Pecan Bayou watershed. Estimates are made of the benefits attributable to the storage of water for these purposes in proposed Federal reservoirs.

Acknowledgments

The cooperation of many persons and agencies is gratefully acknowledged. Special appreciation is expressed to the following:

Bureau of Reclamation, Austin, Texas
Lower Colorado River Authority, Austin, Texas
Central Colorado River Authority, Austin, Texas
Texas Water Commission, Austin, Texas
Texas State Department of Health, Austin, Texas
Brown County Water Improvement District No. 1,
Brownwood, Texas
Coleman Board of Community Development, Coleman, Texas
Brownwood Chamber of Commerce, Brownwood, Texas
Officials of cities in the study area

II. SUMMARY AND CONCLUSIONS

Summary

1. The study area comprises Brown and Coleman Counties and that portion of Callahan County within the Pecan Bayou watershed as shown in Figure 1. It is situated in west-central Texas and contains an area of about 2,600 square miles.
2. The major water users in the study area are the cities of: Brownwood, Coleman, and Cross Plains.
3. The total estimated water resources of the study area in 2020 and 2070 including surface reservoirs, ground water from the relatively unproductive Trinity sand, reusable municipal and industrial return flows, and imports are 41.6 mgd and 45.2 mgd, respectively.
4. The water quality of the existing and firmly planned sources is either acceptable or can be made acceptable for municipal and industrial uses.

Conclusions

1. Efficient development of all of the water resources of the Pecan Bayou watershed is essential to the continued growth of the area. To attain full utilization of these resources for municipal, industrial, agricultural, and recreation purposes will require control of pollution throughout the area. Therefore, provision of water to maintain minimum acceptable quality conditions in the waters of the watershed must be made a part of the water supply plan until such time as future advances in waste treatment technology can economically provide for removal of residual pollutants before they reach the receiving streams.
2. The study area's population is expected to reach 68,400 by the year 2020 and 105,700 by the year 2070.
3. Projected municipal and industrial water needs for the study area are 16.3 mgd (million gallons per day) in 2020 and 26.6 mgd in 2070.

4. With the water supply plan as herein presented, the potential water resource in the Pecan Bayou watershed including imports is sufficient to satisfy all water requirements within the basin until the year 2070.
5. To maintain water quality within the Pecan Bayou watershed will require releases from storage in Coleman and Pecan Bayou Reservoirs of about 1.5 mgd and 2.1 mgd in the years 2020 and 2070, respectively. This is based on hydrologic conditions that may be expected to reoccur once in 10 years.
6. The estimated benefits of storage by purpose in Pecan Bayou and Coleman Reservoirs are shown in Table IX-1, page IX-2.

III. DESCRIPTION OF PROJECT

Location

Pecan Bayou is a tributary of the Colorado River. It rises in Callahan County in central Texas and flows generally southeast 130 miles to its confluence with the Colorado River near the city of Goldthwaite in Mills County. Other major streams in the watershed are Hords Creek and Jim Ned Creek. Hords Creek is a tributary of Jim Ned Creek which in turn flows into Pecan Bayou a short distance above Brownwood Dam.

The watershed is a fan-shaped area approximately 85 miles long and 30 miles wide at its widest point. Portions of the following eight counties are within the watershed's boundaries: Taylor, Eastland, Runnels, Comanche, Mills, Brown, Callahan, and Coleman. The latter three contain the bulk of the drainage area and comprise the study area for purposes of this report.

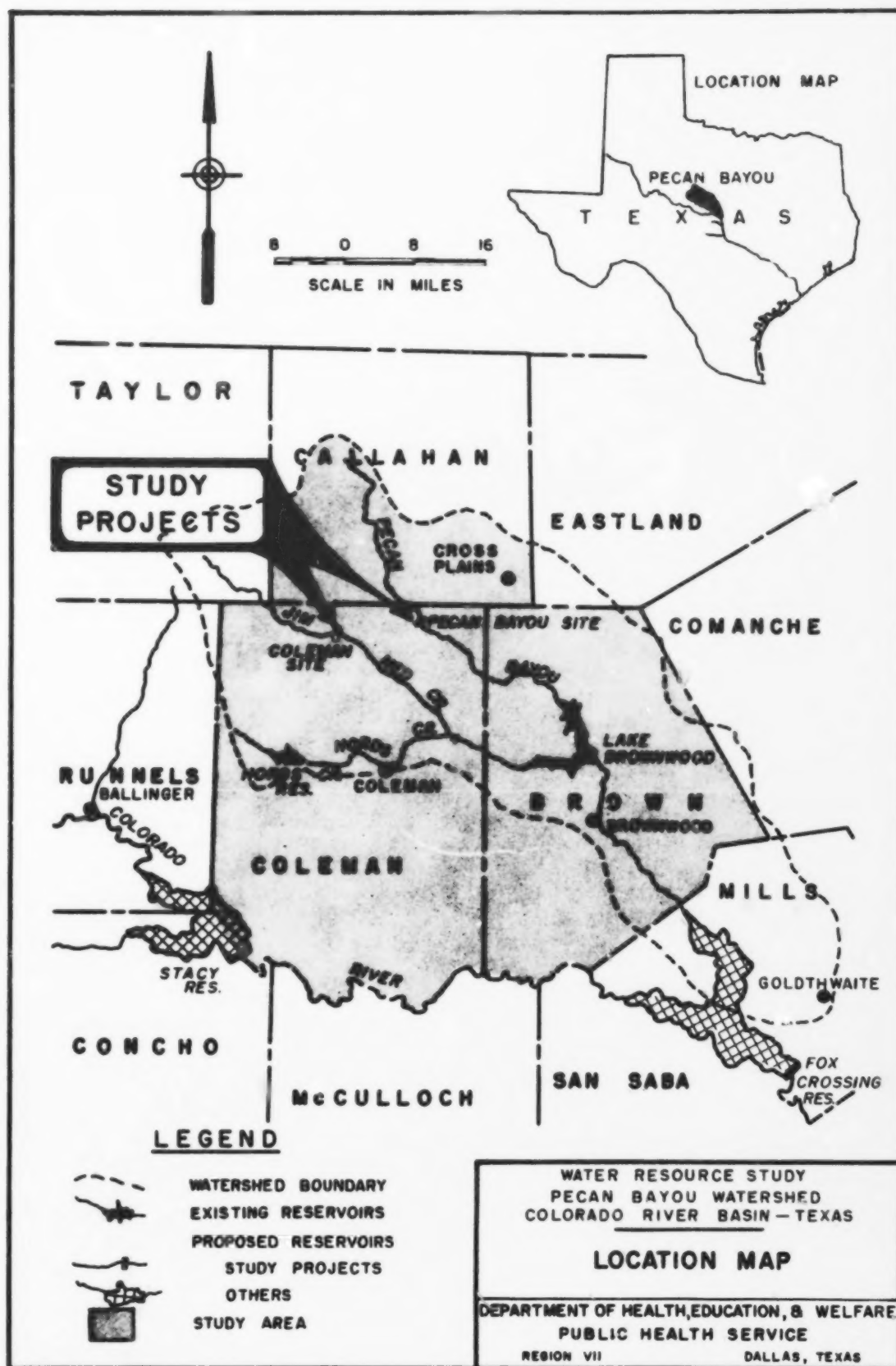
The Pecan Bayou project as used in this study consists of the reconstruction of the Brownwood Dam, construction of Pecan Bayou Reservoir at mile 100.8 on Pecan Bayou, and construction of Coleman Reservoir at mile 52.2 on Jim Ned Creek. The location of the project is shown in Figure 1.

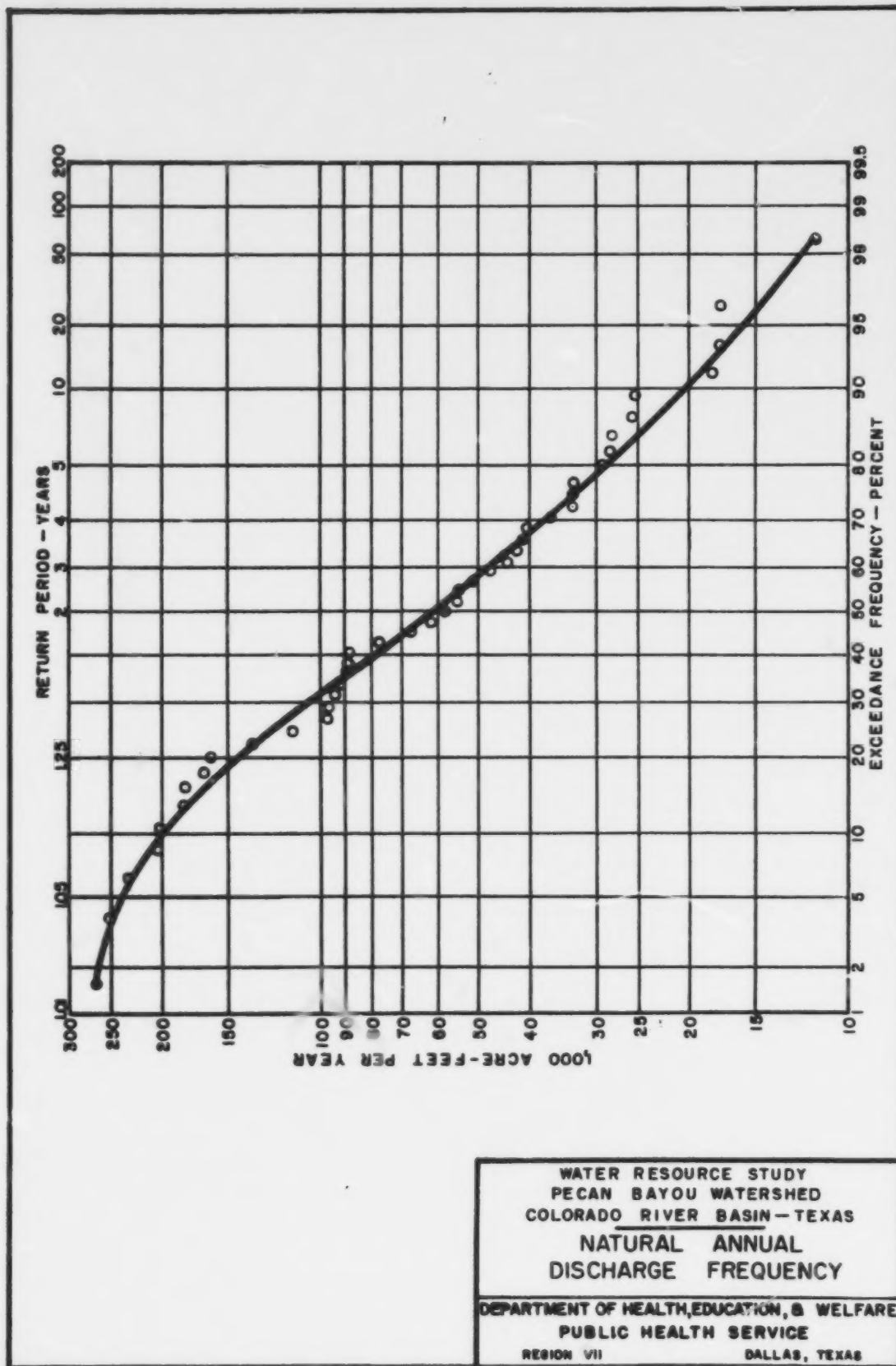
Streamflow

Most of the flow of Pecan Bayou is surface runoff, with little contribution from ground water seepage. The U. S. Geological Survey maintains a gaging station on Pecan Bayou located one mile north of the city of Brownwood and 10 miles downstream from Brownwood Reservoir. The Corps of Engineers supplied estimated natural annual discharges at the Brownwood Dam site for a 43-year period ending in 1958. A discharge frequency curve was constructed from these data and is shown in Figure 2.

Ground Water

Ground water in the study area is practically nonexistent. Small amounts may be found in thin beds of sand in stream alluvium and in the relatively unproductive Trinity sands which underlie the northeastern portion of the area. The U. S. Study Commission-Texas estimated that there were less than 500 acre-feet per year of ground water available in the study area. The Texas Water Commission concurred in a Public Health Service estimate of 2.0 mgd which was made as a part of the water resources study of the Colorado River basin, Texas.





Water Quality

The concentrations of the chemical constituents in Pecan Bayou water are currently within the limits suggested by the Public Health Service Drinking Water Standards--1961. A summary of analyses of biweekly water samples taken from Pecan Bayou at the bridge on U. S. Highway 377 by the Texas State Department of Health are shown in Table III-1.

Table III-1

Water Quality--Pecan Bayou
(Period of Record - 11/12/57 to 3/2/59)

	<u>Concentrations in mg/l.*</u>		
	<u>Total Solids</u>	<u>Chlorides</u>	<u>Sulfates</u>
Arith. Average	318	54	36
Maximum	630	140	105
Minimum	171	20	11

* Milligrams per liter

The city of Cross Plains is the only municipality in the study area presently using ground water. Quality data are sparse but a random sample collected by the Texas State Department of Health in May 1955 showed the following concentrations: total solids, 372 mg/l.; chlorides, 32 mg/l.; and sulfates, 17 mg/l.

The waters of the Pecan Bayou watershed are of satisfactory quality for general municipal and industrial use after conventional treatment.

Pertinent Data

Pertinent data on Pecan Bayou, Coleman, and Brownwood Reservoirs, as determined by the Corps of Engineers, are shown in Table III-2.

Table III-2

Pertinent Data

Storage (Acre-feet)	Reservoir		
	<u>Brownwood</u>	<u>Coleman</u>	<u>Pecan Bayou</u>
Conservation	85,900	138,500	93,520
Sediment	33,000	10,300	10,100
Flood Control	<u>-0-</u>	<u>92,100</u>	<u>102,680</u>
Total	118,900	240,900	206,300
Yield (cfs)*	23	20	13

* The yields shown are based on the worst drouth period of record. The yield of Brownwood Reservoir before the addition of Coleman and Pecan Bayou Reservoirs is 35 cfs (cubic feet per second), and after the addition of the two upstream reservoirs is reduced to 23 cfs. Thus, the addition of Coleman and Pecan Bayou Reservoirs provides a net increase in dependable yield of about 21 cfs of which (on a system-basis proportion) 13 cfs and 8 cfs would be creditable to the Coleman and Pecan Bayou Reservoirs, respectively.

IV. DESCRIPTION OF THE STUDY AREA

Location and Boundaries

The boundaries of the study area are shown in Figure 1. The area is generally coincident with the watershed boundaries of Pecan Bayou to the Mills County line, and it is wholly within the Colorado River basin. The major municipalities in the study area are Brownwood in Brown County; Cross Plains in Callahan County; and Coleman in Coleman County.

Geography

The terrain of the study area is characterized by rather rough, broken relief. The major soil region within the area is the North Central Prairie. This region is characterized by loams and clays which are suitable for the growth of grains, cotton, and truck crops.

The area has a temperate climate with hot summers and cool winters. The mean annual temperature is about 65 degrees, and the mean annual precipitation over the area is approximately 25 inches. The average length of the growing season is on the order of 235 days.

V. ECONOMICS AND POPULATION

Extractive Industries

Mining

The mineral deposits of the study area are many and varied. The following paragraphs describe the mineral extraction activities of each county.

Brown County has produced principally quarried stone and some petroleum. The limited petroleum production has been from shallow, small fields, and recent exploration has not indicated any new fields which could be expected to alter the situation. There were 472,000 barrels produced in 1958. ^{1/}

In Callahan County mineral production consists of oil and natural gas. There were 2,616,000 barrels of oil produced in 1958. ^{1/}

Petroleum production in the Glen Cove and Goldsboro fields of Coleman County accounts for the major portion of the value of mineral production there. The production in 1958 was 2,935,000 barrels. ^{1/} In addition, glass sand and other rock minerals are found in this county.

The value of mineral production for each of the counties for the period 1952 to 1958 is shown in Table V-1. ^{2/}

Table V-1

Value of Mineral Production
(1,000's of 1958 Dollars)

<u>Year</u>	<u>County</u>			<u>Total</u>
	<u>Brown</u>	<u>Callahan</u>	<u>Coleman</u>	
1952	2,115	2,009	8,077	12,201
1953	2,393	5,563	11,875	19,831
1954	2,792	6,689	11,526	21,007
1955	2,417	9,878	11,194	23,489
1956	2,438	11,715	10,476	24,629
1957	2,409	10,427	12,098	24,934
1958	1,996	8,323	11,188	21,507

The total value of all minerals produced in the three counties in 1958 showed an increase of approximately 76 percent over the total of 1952. This increase is significantly greater than the 7 percent increase for the entire State for the same period.

Agriculture

The acres of cropland harvested and the value of all crops sold in the study area have shown an overall downward trend for the period of record as shown in Table V-2. ^{3/} Conversely, the value of livestock and livestock products sold rose sharply in 1959. This activity has become a more important segment of the agricultural economy of the area.

Table V-2

Agricultural Activity in Brown,
Callahan, and Coleman Counties

<u>Year</u>	<u>Cropland Harvested (Acres)</u>	<u>Value of All Crops Sold (1,000's of 1958 \$'s)</u>	<u>Value of Livestock and Livestock Products Sold (1,000's of 1958 \$'s)</u>
1959	161,342	3,645	15,246
1954	273,992	3,258	9,689
1949	409,246	9,073	9,455
1944	394,789	6,322	9,628

Manufacturing

Manufacturing employment in the study area increased 154 percent or 1,000 workers in the two decades from 1940 to 1960. The statewide increase was also 154 percent. This accelerated growth of manufacturing in recent years is characteristic of many parts of the Southwestern States, which before World War II engaged principally in the extraction and primary processing of raw materials. Data on manufacturing activities for the three counties are shown in Table V-3. ^{4/}

Table V-3

Manufacturing Activities

<u>County</u>	<u>Employees</u>			<u>Payroll (\$1,000's)</u>			<u>Value Added (1,000's of 1958 \$'s)</u>		
	<u>1947</u>	<u>1954</u>	<u>1958</u>	<u>1947</u>	<u>1954</u>	<u>1958</u>	<u>1947</u>	<u>1954</u>	<u>1958</u>
Brown	442	604	1,125	851	1,451	3,664	2,236	2,683	6,598
Callahan	47	61	--	--	--	--	--	--	--
Coleman	220	224	254	362	558	689	933	943	1,209
Total	709	889	1,379	1,213	2,009	4,353	3,169	3,626	7,807

Generally, an increase in employment, coupled with increased value added per employee as shown in the table above, reflects favorably on the prospect for continued growth in the manufacturing industries.

Population

The population of the study area was 40,540 in 1960. This is a decrease of 26 percent since 1910, compared to the same period increase of 146 percent for the State of Texas. Closer examination of the records will show, however, that the municipal component of the total population showed an increase of 179 percent during the same five decades, while the nonmunicipal population declined 226 percent. The decrease in agricultural employment and the accompanying increase in manufacturing employment and associated service industries between 1940 and 1960, along with outmigration to larger population centers, are the primary reasons for these population trends. The historical populations are summarized in Table V-4. 5/

Table V-4

Historical Population

<u>Year</u>	<u>Population</u>		
	<u>Total</u>	<u>Municipal</u>	<u>Nonmunicipal</u>
1910	51,041	10,013	41,028
1920	45,497	11,091	34,406
1930	55,459	18,867	36,592
1940	51,388	23,425	27,963
1950	47,954	30,917	17,037
1960	40,540	27,939	12,601

Future Growth

Economic Projections

The projections represent the level of economic activities that can be expected under assumptions of relatively high employment, a trend toward peace, continued population and economic growth, and a stable general price level. In general, the projections reflect the long-term levels that might reasonably be reached with production and requirements in balance under competitive conditions. The study area is endowed with many factors which can be expected to promote economic growth. Raw materials, fuel, power, and climate are some of the more important.

The study area contains over 30,000 acres of potentially irrigable land and some of the best natural rangeland in the entire State. Production, as reflected by the constant dollar values, has leveled off in crops and shown a marked increase in livestock and livestock products sold. Agricultural production in the study area is expected to increase 140 percent by the year 2020. Seventeen

percent of the labor force, or 2,660 workers, were engaged in agriculture in 1960. By 2020, about 9 percent of the labor force, or 2,200 workers, will be sufficient to achieve the expected production.

The minerals industry, which is presently very active, has good promise for expansion. The petroleum and natural gas reserves will probably continue to be utilized at a rate at least equal to the present rate of production. There are deposits of brick clay and silica sand present which can be expected to come into use in the manufacture of brick, pottery, and glass. In 1960 almost 5 percent of the labor force in the area was employed in mining, compared to a statewide average of slightly less than 3 percent. Employment in mining is expected to increase from 724 workers in 1960 to about 900 workers in 2020. This will represent about 3.7 percent of the labor force in 2020.

Growth and diversification of the manufacturing industries will continue in the study area. Resource-oriented manufacturing is expected to grow, especially that associated with food processing; stone, clay, and glass products; petroleum and natural gas; and possibly chemicals. Also, as the population grows, the market-oriented industries such as fabricated metals, machinery, and transportation equipment can be expected to increase. In 1960, 10.5 percent of the labor force, or 1,648 workers, were employed in manufacturing. By 2020, over 18 percent, or 4,500, will be so employed.

The service industries, which include sales, insurance, finance, personal services, and transportation, employed about 63 percent of the labor force, or 9,903 workers, in 1960. Based on past trends modified by relative growth and income in the area, comparable employment in 2020 will be about 16,000 workers or 65 percent of the labor force.

A summary of the present and projected future employment in the study area is shown in Table V-5.

Table V-5

Study Area Employment--Present and Projected

<u>Industry</u>	<u>1960 Labor Force</u>		<u>2020 Labor Force</u>	
	<u>Number</u>	<u>Percent</u>	<u>Number</u>	<u>Percent</u>
Agriculture	2,660	17.0	2,200	8.9
Forestry and Forest Products	4	--	15	0.1
Mining	724	4.6	900	3.7
Manufacturing	1,648	10.5	4,500	18.3
Service Industries	9,903	63.5	16,000	65.0
Unemployed	671	--	--	--
Labor Force	15,610	--	24,600	--

Population Projections

The population of the study area has been decreasing at an annual rate of approximately 0.5 percent. This compares with a same period increase of about 0.875 percent per year in the Colorado River basin area of Texas (of which the study area is a part) and a national average increase of about 1.5 percent per year.

Based on its economic potential, it is reasonable to expect a reversal in the past population trend of the study area to a growth rate at least equal to that experienced in the Colorado River basin, Texas, as a whole. The projected population in the study area is 68,400 by 2020 and 105,700 by 2070.

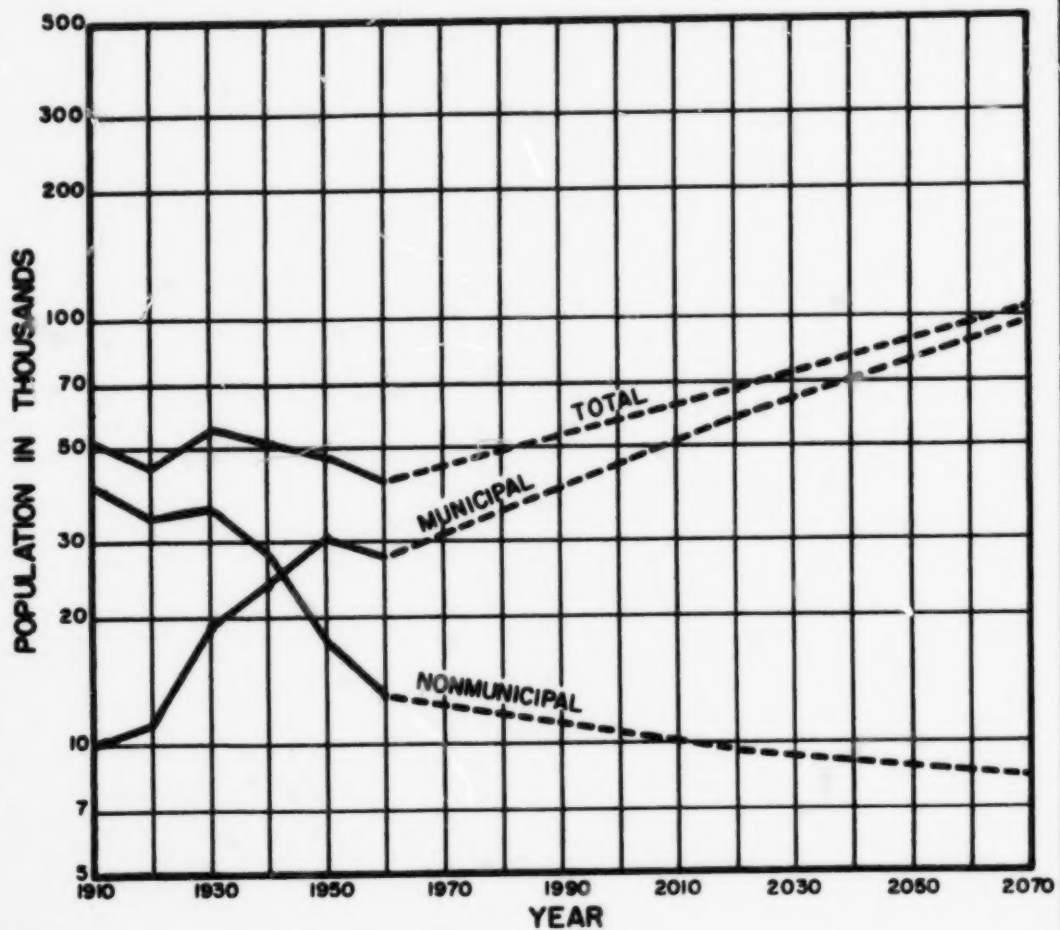
A summary of the population projections is presented in Table V-6* and Figure 3.*

Table V-6

Population Base and Projections

<u>Year</u>	<u>Population</u>		
	<u>Total</u>	<u>Municipal</u>	<u>Nonmunicipal</u>
1960	40,540	27,939	12,601
2020	68,400	58,800	9,600
2070	105,700	97,500	8,200

* Municipal is defined here as including the population of all places of 1,000 or more persons, and nonmunicipal is the classification used for the remainder of the population.



WATER RESOURCE STUDY
PECAN BAYOU WATERSHED
COLORADO RIVER BASIN - TEXAS
POPULATION PROJECTIONS

DEPARTMENT OF HEALTH, EDUCATION, & WELFARE
PUBLIC HEALTH SERVICE
REGION VII DALLAS, TEXAS

FIGURE 3

VI. WATER REQUIREMENTS

General

Under the provisions of Title III, Public Law 85-500, the inclusion of storage to meet present and anticipated future demand or need for municipal and industrial water is authorized in any reservoir project surveyed, planned, or constructed by the Corps of Engineers, U. S. Army. A Memorandum of Agreement dated November 4, 1958, between the Department of the Army and the Department of Health, Education, and Welfare states that the Public Health Service will submit to the Corps of Engineers a report of its views and recommendations on present and prospective needs for municipal and industrial water supply and the desirability of meeting those needs from the project or projects under consideration.

The probable future water requirements of the study area in the year 2020 were based on detailed economic and population projections, coupled with analyses of unit water requirements. The overall unit water use determined for the projected population in 2020 is assumed to remain constant for the period from 2020 to 2070. Therefore, determination of the 2070 water requirements involves population as the only variable.

Municipal Water Use

Municipal water is defined here as municipally supplied water for all purposes excluding that supplied to industrial establishments. Included in the resulting per capita quantities are losses in the distribution system, treatment plants, and terminal reservoirs.

Future municipal water needs are calculated by multiplying the estimated 2020 per capita use by the projected municipal population for the area. The unit municipal water use for the year 2020 is expected to be 200 gallons per capita day. On this basis, the municipal water requirement for the study area is estimated to be 11.8 million gallons per day (mgd) in the year 2020 and 19.5 mgd in 2070.

Industrial Water Use

The definition of industrial water use here refers to all water regardless of source used by the manufacturing industries (Standard Industrial Classification categories 13, 14, and 20 through 39). The total industrial requirements are determined by combining the projected number of employees with the projected unit employee water use for each of the several industrial categories. Industrial water use for the years 2020 and 2070 is estimated to be 1.2 mgd and 2.0 mgd, respectively. The base data were obtained from an industrial survey of the study area, and adjustments have been made for anticipated recirculation and reuse practices.

Power Generation Water Use

Consumptive use of water for thermal power generation is a part of the industrial requirement but is determined separately, since water for this purpose is a function of population rather than employment. Information on future water use was gathered from power companies in the area and combined with data developed by the Federal Power Commission and the Edison Electric Institute for the Senate Select Committee on National Water Resources. The general locations of future power generation installations were determined and the projected needs apportioned throughout the study area according to the service areas for the several generating plants. The water requirements for this purpose are estimated to be 3.3 mgd in the year 2020 and 5.1 mgd in 2070.

Nonmunicipal Water Use

A small segment of the total water need that is sometimes overlooked is that of nonmunicipal water supply for purposes other than irrigation. In an area where the terminal year requirement for all of the water available is anticipated, however, an estimate of this use becomes necessary so as not to understate the total water requirements.

For purposes of this study, the nonmunicipal water requirements are assumed to consist of domestic water for the nonmunicipal population and water for the maintenance of livestock. The 2020 and 2070 requirements for nonmunicipal water are estimated to be 1.7 mgd and 1.5 mgd, respectively, based on a nonmunicipal per capita use of 180 gallons per day.

Other Water Uses

The projected diversion of water for irrigation was furnished by the Corps of Engineers. The quantity for this purpose is 14.8 mgd for both the years 2020 and 2070.

VII. WATER QUALITY CONTROL

General

Under the provisions of the Federal Water Pollution Control Act, Public Law 84-660 as amended, consideration must be given to the inclusion, in any reservoir being planned by a Federal agency, of storage for regulation of streamflow to control water quality. Storage and release of this water are not to be provided as a substitute for adequate treatment or control of wastes at their sources.

To attain full utilization of the water resources of Pecan Bayou for municipal, industrial, agricultural, and recreation purposes will require abatement of present and future pollution. Treatment alone, at the present stage of its development, is not sufficient to achieve desirable stream conditions in the Pecan Bayou watershed.

Provision of storage for the control of water quality will have many benefits. Maintenance of low concentrations of total dissolved solids will improve the competitive position of the area in attracting industry. Preservation of an adequate level of dissolved oxygen will enhance the recreational attractiveness of the stream by providing a balanced ecology. Low flows will be less severe and pest breeding, stagnant pools will be eliminated.

When treatment methods improve, the need for the addition of water to maintain quality will diminish and may someday entirely disappear. Until such time, however, it is essential that recognition be given to the need for flows which must prevail in receiving streams if their water quality is to be maintained at acceptable levels. Therefore, estimates of the water required to maintain quality in the Pecan Bayou watershed have been made since these requirements are an inseparable part of the water supply plan of the study area.

Quality Parameters

The determination of water quality takes into consideration the wastes which will result from the economic development of an area and the effects of these wastes on stream regimen. At any point in a stream, the water quality will be the result of mixing various qualities and quantities of water which make up the total flow modified by forces such as reaeration and evaporation which tend to change its character.

A comprehensive study of water quality requires the analysis of a large number of individual contaminants which occur in most streams. Estimates of pollution are based on water use as a logical outgrowth of present conditions and technology, and quality analysis

is based on broad parameters which are currently available for evaluation of future stream conditions. Total dissolved solids projections are employed to characterize the effects of stable pollutants (those constituents which are not utilized or reduced by stream environment). Dissolved oxygen content is applied as a measure of unstable pollutants (those constituents which decay and act on, or are acted on by, the stream environment).

Stream Loading

The expected amounts of return flow and characteristics of the wastes were estimated and the following assumptions regarding quality control requirements were made.

1. Sufficient treatment will be provided to remove 90 percent of the biochemical oxygen demand and 15 percent of the total dissolved solids.
2. Evaporation and seepage from streams are reflected in streamflow records and require no adjustments. Adjustments for evaporation in reservoirs were necessary, however.
3. Uniform mixing of wastes and receiving waters will occur.
4. Water for quality control is required when the dissolved oxygen content of the mixed water in the stream is below 4.0 milligrams per liter (mg/l.) or the total dissolved solids exceed 500 mg/l.

Allowances for Streamflow

In determining the amount of water from storage required to preserve the quality of the stream, it is necessary to make allowances for natural flows that can be expected to occur in the stream. A discharge frequency analysis of the stream based on monthly flows was made from 43 years of data furnished by the Corps of Engineers. Calculations were then performed to determine the amount of regulation water from storage required to maintain quality in the stream for hydrologic conditions that could be expected to reoccur in the watercourse every 5, 10, 20, and 50 years, respectively.

Need for Water for Quality Control Purposes

An analysis of the watershed was made on a Bendix G-15 computer. The computations based on the above assumptions indicated the following:

1. The waters of the basin will not be degraded below acceptable limits by the stable pollutants (total dissolved solids).
2. Organic pollution in the reach of Pecan Bayou below the city of Brownwood exceeds the assimilative capacity of the stream and will require release of water from storage to maintain an acceptable oxygen balance in the stream.

A summary of the water required for quality control purposes in Pecan Bayou below the city of Brownwood is shown in Table VII-1. The maximum monthly requirements are independent of recurrence because the base flow during the maximum month is zero at the five-year recurrence interval.

Table VII-1

Water Requirements for Quality Control Purposes (mgd)

<u>Year and Condition</u>	<u>Recurrence Interval in Years</u>			
	<u>5 Year</u>	<u>10 Year</u>	<u>20 Year</u>	<u>50 Year</u>
1960				
Maximum Month	3.5	3.5	3.5	3.5
Minimum Month	0	0	0	0
Average Annual	1.0	1.1	1.3	1.4
2020				
Maximum Month	4.8	4.8	4.8	4.8
Minimum Month	0	0	0	0
Average Annual	1.3	1.5	1.7	1.9
2070				
Maximum Month	6.5	6.5	6.5	6.5
Minimum Month	0	0	0	0
Average Annual	1.8	2.1	2.3	2.5

The 10-year recurrence interval was chosen for the purpose of evaluating benefits for quality control after consideration of the following items.

1. Length of affected stream--approximately 15 miles. Pecan Bayou drains into the proposed Fox Crossing Reservoir on the Colorado River about 15 miles below the last point of pollution. The additional dilution available in this reservoir is sufficient to assimilate the wastes even for the 50-year recurrence interval without adverse effects on the stored water.

2. Prospective downstream uses--for normal recreation and agricultural pursuits.
3. Historical flows--records indicate that Pecan Bayou is an intermittent stream.
4. Quantity of quality control water available--limited. The amount of water available for quality control within the watershed is necessarily limited if the water resources of the basin are to be developed to provide for the several anticipated uses. The use of the 10-year frequency will keep importation into the watershed at a minimum.

Operations Plan to Maintain Water Quality

Operation of the watershed according to the plan outlined in the following section on supplying future requirements will restrict the need for quality control water to the reach of Pecan Bayou below Brownwood Reservoir. On this assumption, it is reasonable to distribute the quality control requirement between Coleman and Pecan Bayou Reservoirs. The plan calls for releases of stored water from these upstream reservoirs to Brownwood Reservoir, which will act as a terminal reservoir for the release of the quality control requirements.

It is recommended that storage sufficient to provide for average annual releases of 1,232 acre-feet and 1,120 acre-feet be provided in Coleman and Pecan Bayou Reservoirs, respectively. Regulation of these amounts to meet the varying monthly needs for quality control would then be accomplished in Brownwood Reservoir.

VIII. PLANS FOR SUPPLYING FUTURE WATER REQUIREMENTS

General

The estimated 2020 municipal and industrial water need in the study area is 16.3 mgd. Of this total, it is expected that 0.3 mgd will be supplied from ground water and the remaining 16 mgd from surface sources. In addition, the projected nonmunicipal requirements of 1.7 mgd are expected to be satisfied wholly from ground water; and, of the projected irrigation needs of 14.8 mgd, expectations are that 12.3 mgd will be supplied from the watershed reservoirs and 2.5 mgd from municipal and industrial return flows. A summary of supply sources for the year 2070 is shown in Table VIII-1.

Table VIII-1

Summary of Study Area Supply Sources--2070

<u>Source</u>	<u>Amount (mgd)</u>
Ground water for municipal and industrial use	0.3
Ground water for nonmunicipal use	1.5
Surface water for municipal and industrial use	26.3
From: Pecan Bayou watershed	24.4
Imports from Colorado River basin	1.9
Stacy Reservoir	1.1
Fox Crossing Reservoir	0.8
Surface water for irrigation	14.8
From: Pecan Bayou watershed	10.6
Reuse of municipal and industrial return flows	4.2
Surface water for quality control	2.1
From: Pecan Bayou watershed	2.1

The plans for supplying water to the study area by counties for the years 2020 and 2070 are shown in Tables VIII-2 and VIII-3. A water balance for the watershed for the years 2020 and 2070 is shown in Table VIII-4.

Table VIII-2

2020 Water Supply Plan
(All quantities in mgd)

Area and Use	Total Need	Estimated Ground Water Use	Surface Supply Need	Surface Supply		Estimated Return Flow	Disposition of Return Flow		
				Source	Amount		Disposal Stream	Gaining Reservoir	Amount Returned
Callahan Co.									
M & I	1.0	0.3	0.7	Pecan Bayou Res.	0.7	0.5	Pecan Bayou	Brownwood	0.5
Nonmun.	0.2	0.2	0						
Irrig.	0	0	0						
TOTAL	1.2	0.5	0.7						
Coleman Co.									
M & I	5.2	0	5.2	Hords Cr. Res.	0.9	2.0	Hords Cr.	Brownwood	2.0
Nonmun.	0.7	0.7	0	Coleman Res.	4.3				
Irrig.	0	0	0						
TOTAL	5.9	0.7	5.2						
Brown Co.									
M & I	10.1	0	10.1	Brownwood Res.	14.9	8.5*	Pecan Bayou	Fox Crossing	8.5*
Nonmun.	0.8	0.8	0	Pecan Bayou Res.	6.7				
Irrig.	14.8	0	14.8	Coleman Res.	2.3				
TOTAL	25.7	0.8	24.9	Return Flows	1.0				

* Composed of 4.1 mgd of municipal and industrial return flows and 4.4 mgd of irrigation return flows.

Table VIII-3

2070 Water Supply Plan
(All quantities in mgd)

Area and Use	Total Need	Estimated Ground Water Use	Surface Supply Need	Surface Supply		Estimated Return Flow	Disposition of Return Flow		
				Source	Amount		Disposal Stream	Gaining Reservoir	Amount Returned
Callahan Co.									
M & I	1.7	0.3	1.4	Pecan Bayou Res.	1.4	0.9	Pecan Bayou	Brownwood	0.9
Nonmun.	0.2	0.2	0						
Irrig.	0	0	0						
TOTAL	1.9	0.5	1.4						
Coleman Co.									
M & I	8.5	0	8.5	Hords Cr. Res.	0.9	3.3	Hords Cr.	Brownwood	3.3
Nonmun.	0.6	0.6	0	Coleman Res.	6.5				
Irrig.	0	0	0	Stacy Res.*	1.1				
TOTAL	9.1	0.6	8.5						
Brown Co.									
M & I	16.4	0	16.4	Brownwood Res.	14.9	11.1**	Pecan Bayou	Fox Crossing	11.1**
Nonmun.	0.7	0.7	0	Pecan Bayou Res.	6.0				
Irrig.	14.8	0	14.8	Coleman Res.	5.3				
TOTAL	31.9	0.7	31.2	Fox Crossing Res.* Return Flows	0.8 4.2				

* Stacy and Fox Crossing Reservoirs are located on the Colorado River outside the Pecan Bayou watershed.

** Composed of 6.7 mgd of municipal and industrial return flows and 4.4 mgd of irrigation return flows.

Table VIII-4

2020 and 2070 Water Balance
(All quantities in mgd)

Reservoir Yields	Resources			Requirements					
	Imports	Ground Water	Reused Water	Total	Munic. and Indus.	Non- munic- ipal	Water Quality Control	Irrig- ation	Total
For the Year 2020									
37.1	0	2.0	2.5	41.6	16.3	1.7	1.5	14.8	34.3
				Surplus: 7.3 mgd					
For the Year 2070									
37.1	1.9*	2.0	4.2	45.2	26.6	1.5	2.1	14.8	45.0
				Surplus: 0.2 mgd					

* From Stacy and Fox Crossing Reservoirs on the Colorado River.

IX. BENEFITS OF STORAGE

Evaluation Method

The report of the Sub-Committee on Evaluation Standards of the Federal Inter-Agency Committee on Water Resources makes the following comment on evaluation of municipal and industrial water supply:

"From an over-all public viewpoint, a municipal and industrial water supply development will be economically justified if it provides water to meet expected needs at a cost not greater than the cost of the alternative source that would likely be utilized in the absence of the project."

The alternative cost method has been used for evaluation of all storage proposed in this report.

Costs

For purposes of comparison of alternatives, the Corps of Engineers converted capital costs of the alternatives to equivalent annual costs, and added estimated annual operation, maintenance, and replacement costs. The "present" (1970) value of the costs so determined for the date of first use of the project is shown in this report.

Alternative Plans

Benefits are calculated for Coleman and Pecan Bayou Reservoirs. The alternatives used for Coleman and Pecan Bayou Reservoirs are single-purpose reservoirs at the project sites since the watershed contains no appreciable ground water and the project sites are the most economical available.

Some of the benefits resulting from storage of water for quality control at these sites are: (1) improvements in the areal industrial "climate" and recreational facilities; and (2) elimination of nuisances caused by low flows.

A yield-requirement analysis determined a need for water supply and/or water quality storage in both Coleman and Pecan Bayou Reservoirs by the year 1980. The benefits attributable to these projects are shown in Table IX-1. The benefits are prorated by purpose according to the yield reserved for that purpose.

Table IX-1

Benefits of Storage in Pecan Bayou and Coleman Reservoirs

<u>Project</u>	<u>Creditable Yield (cfs)</u>	<u>Annual Benefits (\$)</u>
Pecan Bayou		
Total	8.0	253,700
Water Supply	6.5	206,100
Quality Control	1.5	47,600
Coleman		
Total	13.0	314,200
Water Supply	11.3	273,100
Quality Control	1.7	41,100

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